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## ON CORUNDUM-SYENITE (URALOSE) FROM MONTANA

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Specimens of a corundum-bearing rock from the property of the Bozeman Corundum Company, fourteen miles southwest of Bozeman, Gallatin County, Mont., were obtained for Stanford University by Mr. R. M. Wilke of Palo Alto, Cal. No information concerning the country rock could be obtained except the statements of Pratt in his monograph on corundum:<sup>1</sup> "The corundum seams vary from a few inches to three feet in thickness. . . . Bozeman: Fourteen miles southwest of this town corundum is found in syenite." From this it would seem that the country rock as a whole is a syenite with bands or seams of the corundum rock. These bands, the writer will show, are corundum-syenite. The rarity of this type of igneous rock accounts for the present paper.

Corundum-syenites have been described only from the Urals,<sup>2</sup> from eastern Ontario,<sup>3</sup> and from the Coimbatore district, India.<sup>4</sup>

The corundum-syenite is a medium to coarse-grained, gray-mottled, more or less banded rock, the banding due principally to the fact that the biotite flakes are mostly in parallel position, though the other minerals are occasionally in rough, parallel position. The gneissoid corundum-syenite, as it may be characterized, is composed of microcline-perthite, biotite, and corundum with subordinate sillimanite, muscovite, zircon, and baddeleyite. The feldspar is for the most part a perthitic intergrowth of microcline and albite, though one slide shows plagioclase, orthoclase, and microcline without any perthite. On a section of the microperthite parallel to {001} the microcline has an extinction angle of  $11\frac{1}{2}^{\circ}$ , and the albite, one of  $4\frac{1}{2}^{\circ}$ . In this section the albite shows only very faint albite twinning. On a section parallel to {010} the microcline has an extinction of  $-3^{\circ}$  and the albite, one of  $+20^{\circ}$ .

<sup>1</sup> *Bull. No. 269, U.S.G.S.*, 133, 144 (1906).

<sup>2</sup> Morozewicz, *Min. u. petr. Mitth.*, XVIII, 217 (1898).

<sup>3</sup> Miller, *Rept. Bureau of Mines*, Toronto, Canada, VIII, Part 8, 210 (1899).

<sup>4</sup> Holland, *Mem. Geol. Surv. of India*, XXX, Part 3, 169 (1901).

The feldspar crystals are sometimes arranged in rough *augen*. The corundum occurs in grayish-blue crystals with an average size of 5 mm. and a maximum size of about 2 cm. The corundum crystals are tabular or prismatic in habit with the common forms:  $c$  {0001},  $a$  {1120},  $r$  {1011},  $n$  {2243}, and  $\theta$  {8.8.16.3}. The most frequent combination is *acrn*.

The corundum is often surrounded by a zone of feldspar, which is nearly free from biotite. A fibrous mineral occasionally observed proves to be sillimanite as tested in fragments. Muscovite is often observed in thin, cleavable flakes. It does not appear to be an alteration of the corundum. Thin sections show a very small amount of zircon in minute prismatic crystals. The baddeleyite is a black, submetallic mineral which is usually found between the corundum and the feldspar. It occurs in rounded blebs and in prismatic crystals not over 3 mm. in size and usually only about 1 mm. in greatest dimension. The baddeleyite will be described by the author in a forthcoming number of the *American Journal of Science*.

Baddeleyite rather than zircon forms in this type of rock probably on account of the low silica percentage.

A rock sample weighing 243.6 grams was crushed, and after sizing, the constituents were separated by means of Thoulét solution. It was found that good separations could be made by panning with the Thoulét solution. The following shows the amounts of the various minerals and also the percentages by weight, assuming the loss to be equally distributed among the minerals:

	Grams	Percentage
Feldspar.....	136.6	62.7
Corundum.....	67.3	30.9
Biotite.....	12.6	5.8
Baddeleyite.....	1.1	0.5
Loss.....	26.0	
Total.....	243.6	99.9

We may assume the feldspar to be a eutectic of albite and orthoclase. Vogt gives the eutectic ratio for these two minerals as  $ab=58$  per cent,  $or=42$  per cent. We then have 36.4 per cent albite and 26.3 per cent orthoclase. The biotite is the only mineral

which does not have a fixed chemical composition. We may, however, assume the following percentages which are average values for biotite  $\text{SiO}_2=37$  per cent,  $\text{Al}_2\text{O}_3=16$  per cent,  $\text{Fe}_2\text{O}_3=6$  per cent,  $\text{FeO}=15$  per cent,  $\text{MgO}=12$  per cent,  $\text{K}_2\text{O}=10$  per cent,  $\text{H}_2\text{O}=4$  per cent.

The recalculated chemical analysis of the rock given is as follows:

	Orthoclase	Albite	Corundum	Biotite	Baddeleyite	Total
$\text{SiO}_2$ .....	17.0	25.0	...	2.1	...	44.1
$\text{Al}_2\text{O}_3$ .....	4.8	7.1	30.9	0.9	...	43.7
$\text{Fe}_2\text{O}_3$ .....	...	...	...	0.3	...	0.3
$\text{FeO}$ .....	...	...	...	0.9	...	0.9
$\text{MgO}$ .....	...	...	...	0.7	...	0.7
$\text{CaO}$ .....	...	...	...	...	...	...
$\text{Na}_2\text{O}$ .....	...	4.3	...	...	...	4.3
$\text{K}_2\text{O}$ .....	4.4	...	...	0.6	...	5.0
$\text{H}_2\text{O}$ .....	...	...	...	0.2	...	0.2
$\text{ZrO}_2$ .....	...	...	...	...	0.5	0.5
	26.2	36.4	30.9	5.7	0.5	99.7

Chemically, this is a peculiar rock on account of the high alumina and low silica content. It may be called a corundum-syenite. In order to place this rock in the new quantitative classification it is necessary to convert the percentage compositions of the oxids into percentages of the standard minerals, which in this case are nearly the same as the actual minerals. In other words, the mode and the norm agree closely, biotite being practically the only critical mineral. The calculated norm of the rock is shown in table on p. 751.

All the potash goes into the orthoclase molecule, all the ferric iron and an equivalent amount of the ferrous iron go to make the magnetite molecule. The remaining ferrous oxid goes with all the magnesia to form the hypersthene molecule which requires an equivalent amount of silica. The silica remaining after deducting that required for the orthoclase, hypersthene, and zircon would naturally go into the albite molecule, but it is found that there is too much soda for this amount of silica so that the silica and soda must be distributed between the albite and nephelite according to the equations:<sup>1</sup>

$$\begin{aligned}x + y &= \text{molecules of Na}_2\text{O} \\ 6x + 2y &= \text{available SiO}_2\end{aligned}$$

<sup>1</sup> *Quant. Class. of Igneous Rocks*, 194 (1903).

in which  $x$  is the albite molecule and  $y$  the nephelite molecule. The remaining alumina goes into the corundum molecule.

	Or	Mt	Hy	Z	Ab	Ne	C
SiO <sub>2</sub> = 44.1	19.1	...	1.7	0.2	22.1	1.0	...
Al <sub>2</sub> O <sub>3</sub> = 43.7	5.4	...	...	...	6.3	0.8	31.2
Fe <sub>2</sub> O <sub>3</sub> = 0.3	...	0.3	...	...	...	...	...
FeO = 0.9	...	0.1	0.8	...	...	...	...
MgO = 0.7	...	...	0.7	...	...	...	...
Na <sub>2</sub> O = 4.3	...	...	...	...	3.8	0.5	...
K <sub>2</sub> O = 5.0	5.0	...	...	...	...	...	...
ZrO <sub>2</sub> = 0.5	...	...	...	0.5	...	...	...
	29.5	0.4	3.2	0.7	32.2	2.3	31.2

Orthoclase	= 29.5	F	}	Salic
Albite	= 32.2			
Nephelite	= 2.3			
Corundum	= 31.2			
Zircon	= 0.7	M	}	Femic
Magnetite	= 0.4			
Hypersthene	= 3.2			
Total	= 99.5			

The classification of the rock according to the new quantitative system is as follows:

$\frac{\text{Sal}}{\text{Fem}}$	$= \frac{95.9}{3.6} > \frac{7}{1}$	Class I, Persalone
$\frac{\text{F}+\text{L}}{\text{C}+\text{Z}}$	$= \frac{64.0}{31.9} > \frac{7}{1} < \frac{5}{3}$	Subclass II, Persalone
$\frac{\text{L}}{\text{F}}$	$= \frac{2.3}{62.7} < \frac{1}{7}$	Order 5, Perfelic
$\frac{\text{K}_2\text{O}' + \text{Na}_2\text{O}'}{\text{CaO}'}$	$= \frac{123}{0} > \frac{7}{1}$	Rang 1, Peralkalic
$\frac{\text{K}_2\text{O}'}{\text{Na}_2\text{O}'}$	$= \frac{54}{69} > \frac{3}{5} < \frac{5}{3}$	Subrang 3, Sodipotassic

The magmatic name of this subrang is uralose and the magmatic symbol I<sup>2</sup>, 5, 1, 3. Only two rocks have previously been assigned<sup>1</sup> to uralose, a corundum-syenite and a corundum-pegmatite, both from the Urals.

<sup>1</sup> Washington, *Professional Paper*, U.S.G.S., No. 14, 217 (1903).